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Application of Principal Component Analysis on Collective Flow

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Various flow observables, defined based on the Fourier decomposition, have provided valuable information on the initial state fluctuations, final state correlations and the QGP properties. In spite of the success of the flow measurements and the hydrodynamic descriptions, one essential question is why the Fourier expansion is a natural way to analyze the flow data. In this talk, I will address this question with one of the machine learning techniques, called the Principal Component Analysis (PCA). In more details, we will investigate if a machine (unsupervised learning technique) could directly discover flow from the huge amount of data of the relativistic fluid systems without explicit instructions from human beings.

After apply PCA to the raw data of hydrodynamic simulations, we found that the obtained PCA eigenvectors are similar to but not identical with the traditional Fourier bases. Correspondingly, the PCA defined flow harmonics vn are also similar to the traditional vn for n = 2 and 3, but largely deviated from the Fourier ones with n≥4 . A further study on the symmetric cumulants and the Pearson coefficients indicates that mode-coupling effects are reduced for these flow harmonics defined by PCA. Our work also demonstrated the hydrodynamic system is not highly non-linear as generally believed before, which should be reevaluated with such PCA bases for the flow definition.

[1] Z. Liu, W. Zhao and H. Song, arXiv:1903.09833 [nucl-th]

Primary author: SONG, Huichao (Peking U)

Co-authors: LIU, Ziming (Peking University); ZHAO, wenbin (Peking University)

Presenter: SONG, Huichao (Peking U)

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